PCT / SE 2004 / 0 0 1 2 7 6

PRV

PATENT- OCH REGISTRERINGSVERKET
Patentavdelningen

**Intyg**
**Certificate**



*Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.*

*This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.*

PATENT- OCH REGISTRERINGSVERKET • P

(71) *Sökande* Resys AB, Malmö SE
*Applicant (s)*

(21) *Patentansökningsnummer* 0302349-6
*Patent application number*

(86) *Ingivningsdatum* 2003-09-03
*Date of filing*

*Stockholm,* 2004-09-20

*För Patent- och registreringsverket*
*For the Patent- and Registration Office*

Gunilla Larsson

*Avgift*
*Fee*



**PRIORITY DOCUMENT**
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

**PATENT- OCH REGISTRERINGSVERKET**
SWEDEN

Postadress/Adress
Box 5055
S-102 42 STOCKHOLM

Telefon/Phone
+46 8 782 25 00
Vx 08-782 25 00

Telex
17978
PATOREG S

Telefax
+46 8 666 02 86
08-666 02 86

# AIR CLEANING DEVICE

## FIELD OF INVENTION

The invention relates to an air cleaning device, comprising at least a copper-zinc alloy and a method to clean polluted air, such as, air inhaled after smoking tobacco products or in a smoke-filled environment, and air passing through domestic and industrial ventilation and exhaust systems, including those used in transportation vehicles.

## BACKGROUND OF THE INVENTION

Technological progress in the world today has brought with it accompanying social and environmental problems. Among the latter, air pollution is dominant. Efforts are presently being made to elevate air fouling problems stemming from sources including industrial and engineering production, and exhaust from motorised vehicles. Stricter regulatory controls and laws have been imposed in order to safeguard society's health and the environment.

The International Agency for Research on Cancer (IARC) currently lists 88 individual chemical agents as "Group 1 Human Carcinogens" (IARC monographs, Vols. 1-82, 1987) A substantial number of these agents exist in polluted air, which highlight the urgency for solving pollution problems.

In this context, new and more effective filtering or cleaning devices or systems, used in parallel to more structural and legislative changes, would greatly contribute towards lessening health and environmental hazards imposed by air pollution.

Smoking constitutes another, albeit self-imposed, air pollution risk. Of the 88 chemical agents listed as carcinogens, at least 9 have been reported to occur in mainstream cigarette smoke as part of the tar or residue component which include metals such as cadmium, nickel, chromium, beryllium and arsenic. The other agents include toxic organic substances such as benzene, vinyl chloride, 2-napthyl-amine, and 4-aminobiphenyl.

A different relative risk of lung cancer between smokers using filter and plain cigarettes has been indicated; the risk appears to be 36% lower in filter than in plain cigarette smokers. As filter cigarettes reduce the level of tar consumed by

smokers, a relation between the level of tar consumed and risk of cancer is anticipated.

Over the last 40 years, the level of both tar and nicotine in cigarettes has decreased. Reducing the level of nicotine, may, however, encourage more frequent smoking and in this way, ironically, raise the level of tar consumed. Thus, there is also a need for new filter systems in tobacco products which are able to significantly reduce tar level without influencing the nicotine level.

In the area of water purification, processes utilising ion-exchange resins (IER), activated charcoal or carbon (AC), as well as the concept of reverse osmosis (RO) have been employed. The success of the RO process depends in large part upon the development of suitable membranes.

Yet each of these methods suffer some intrinsic problems, which include saturation of the available sites and the need for constant regeneration (in IER and AC) and the sensitivity and vulnerability of the membranes (in RO).

US Patent 5,433,856 describes a fluid treating method and apparatus for reducing hardness in water consisting of a bed of finely divided metal particulate matter comprising copper and/or zinc, or an alloy of copper and zinc. The metal particulate matter possesses a reduction-oxidation (redox) potential which, relative to the redox potential of the undesirable constituents, favours spontaneous oxidation-reduction reactions between the metal and the undesirable constituents, which include bacteria.

A similar filter medium known as "redox alloy medium (RAM)", which is a high purity copper-zinc alloy, has been employed in water purification. Oxidation-reduction reactions in this system allow removal of dissolved gases such as chlorine, hydrogen sulphide, methane from contaminated water. The same or related redox reactions in RAM also allow removal of soluble heavy metals, and prevention of hardness scale accumulation. RAM is commonly been used in conjunction with other filtration media.

Additionally, RAM is reported to eliminate or reduce the level of microorganisms when redox reactions occurring produce a significant potential shift, which disrupt cellular membranes resulting in microbial death. Also, hydroxyl radicals and hydrogen peroxide, produced for example, during the oxidation of ferrous iron to ferric iron, are toxic to microorganisms.

However, the useful properties of RAM have been applied exclusively for water purification, while a critical demand for new and more effective filtering or cleaning devices or systems to combat air pollution exists.

## SUMMARY OF THE INVENTION

We have now found that RAM, a copper-zinc alloy, may function as an effective air cleaning device or filter.

More specifically, we have found that RAM, a copper-zinc alloy, is able to effectively bind a large number of substances classified as carcinogens or toxic agents. These include metals such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead. In tobacco products such as cigarettes, for example, RAM has been found to reduce the heavy metal content in cigarette tar by 50-70 % after use.

Accordingly, the invention relates to an air cleaning device suitable for cleaning air polluted with metals such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and lead. The air cleaning device possesses improved properties compared to conventional air cleaning devices, such as low cost, high affinity, long service life, ease of use, non toxicity and environmental compatibility.

According to a first embodiment, the invention relates to an air cleaning device, comprising at least a copper-zinc alloy.

According to a second embodiment, the invention relates to a method to remove pollutants from polluted air comprising the steps of; providing an air cleaning device, allowing polluted air to pass through the air cleaning device, allowing the pollutants to bind to the air cleaning device and obtaining air free of the pollutants. The method may include the employment of steam during the use of the air cleaning device.

According to a third embodiment the invention relates to a device for filtering microorganisms found in polluted air passing through domestic and industrial ventilation and exhaust systems, including those used in transportation vehicles.

Another object of the present invention is to provide a method and a device for cleaning air that is economical to use, has a relatively long life so as to avoid frequent maintenance and monitoring, and is non toxic to mammals such as humans and other animals.

The air cleaning device may be used for the cleaning of polluted air inhaled after smoking tobacco products or inhaled through being present in a smoke-filled environment, and polluted air passing through domestic and industrial ventilation and exhaust systems, including those used in transportation vehicles.

## DESCRIPTION OF THE DRAWINGS

The invention will be described in greater detail below, with reference to the figures shown in the appended drawings, in which:

Figure 1 shows the experimental set-up of the filter test in cigarettes.

Table 1 compares the amount of heavy metal present in a smoked and unsmoked RAM filter membrane.

Table 2 compares the amount of heavy metal present in a smoked filter membrane with and without RAM.

## DETAILED DESCRIPTION OF THE INVENTION

<u>Definitions</u>

In the context of the present application and invention the following definitions apply:

The term "pollutants" is intended to mean components in air which are contaminated, and therefore undesirable for inhalation, consumption or contact with, which may be classified as toxic and/or carcinogenic to mammals such as humans and animals, and/or which are environmentally unfriendly. These "pollutants" therefore require removal from the air. The pollutants may either be metallic, organic or inorganic in nature, porous or particulate, in solid, liquid or gaseous form, and include living entities such as microorganisms including bacteria.

The term "redox alloy media" may be used interchangeably with "RAM" or "the alloy" in the specification.

Air cleaning device

The invention relates to an air cleaning device, comprising at least a copper-zinc alloy such as a redox alloy media (RAM). The alloy is in particulate or granulate form and may have varying mesh size, from about 4 to about 400 mesh, based on US Standard screen sizes. A distribution of mesh size is anticipated to be present in the alloy granulate.

The metal particulate matter comprising the alloy may be supplied in other alternate forms such as in aggregate porous bodies made by adhering the particulate matter onto porous bodies of any shape, formed by techniques such as sintering or alternative processes wherein binders are utilized.

The ratio by weight of copper:zinc in the alloy is about 50:50, such as about 40:60, such as about 25:75, when used as earlier described in this application.

The alloy is capable of binding/adsorbing/removing pollutants from air. Specifically, the air cleaning device is capable of binding metals such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead.

Mechanistically, the air cleaning device removes pollutants through oxidation-reduction reactions between the RAM component and the pollutants found in the air which require removal, for example, cigarette tar or heavy metal pollutants, said reaction resulting in the deposition of the pollutants on the filter surface.

The filter may then be regenerated by melting the alloy down, reshaping to the desired form and reusing.

In another embodiment of the invention, the employment of steam may accompany the use of the device. Pre-spraying the filter with a liquid, such as water (heated or unheated) before use may be envisaged. Some acceleration or enhancement of the redox reactions has been surmised, which might lead to an increase in the effectivity and productivity of the device. However, the presence of water is not per se necessary to the functioning of the invention.

The zinc in the alloy component of the air cleaning device is more reactive than copper and more electropositive. Within the alloy component, multitudes of granular high-purity bimetallic couples with copper as the permanent cathode and

zinc as the sacrificial anode may be found. The metals are given a value of -0.76 volts and copper +0.36 volts. The net result is 1.12 volt difference with zinc as the electric donor. A number of elemental metals and metallic alloys will provide the redox potential.

In the case of reaction with a heavy metal, for example, lead (Pb), the reaction my be depicted as follows:

$$Cu/Zn_o + Pb^{2+}(NO_3)_2 = Zn/Cu/Pb_o + Zn^{2+}\ (NO_3)_2\ ^{2-}$$

(where Cu represents copper, Zn represents zinc, Pb represents lead, $(NO_3)_2$ represents nitrate)

In the reaction, zinc loses 2 electrons (i.e, is oxidised), while lead gains 2 electrons (i.e., is reduced). Lead thus deposits on copper and replaces zinc, which goes into solution as ions.

The air cleaning device may be used for all kinds of air cleaning when the pollutants as mentioned before are to be removed from air.

According to one embodiment, use of the air cleaning device for filtering smoke inhaled through the use of tobacco products allows the removal of the heavy metal content in tar of more than 50%, such as from about 50% to about 70 %, such as up to 90%.

Besides reducing the general tar level, the air cleaning device can remove specific heavy metals, such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead. Some of these, especially the heavy metals, are known or suspected to be carcinogens. Thus the air cleaning device both reduces the general tar level as well as removes metals known or suspected to be carcinogens.

However, at the same time, the air cleaning device does not reduce the nicotine level nor influence the function of suction from cigarettes. The air cleaning device thus shows several advantages over present day filter systems for tobacco products, including systems based on activated charcoal.

According to another embodiment, the invention relates to an air cleaning device which remove pollutants from exhaust gases from all kinds of vehicles or machines, especially those requiring petrol or diesel to function. Examples of vehicles include cars, buses, boats and motorcycles.

The invention also relates to an air cleaning device which may be used in

ventilation systems to remove pollutants including microorganisms, such as in domestic and industrial ventilation systems, including those used in transportation vehicles. Examples are these are those employed in hospitals or other institutions which are densely populated.

In this case, the alloy RAM acts as a filter when the oxidation-reduction reactions occurring produce significant potential shifts which disrupt cellular membranes resulting in microbial death. Additionally, the hydroxyl radicals and hydrogen peroxide, produced for example, during the oxidation of ferrous iron to ferric iron, are toxic to microorganisms.

A method to clean contaminated air

Accordingly, the invention relates to a method to remove pollutants from polluted air comprising the steps of; providing an air cleaning device as described above, allowing polluted air to pass through the air cleaning device, allowing the pollutants to bind to the air cleaning device and obtaining air substantially free of pollutants. An additional step of applying steam may be used in between providing the air cleaning device and allowing polluted air to pass through the device.
The particle size dimensions, mesh size, final shape and size, weight, thickness and volume of the copper-zinc alloy component in the air cleaning device needs to be determined from case to case with respect to the application, to ensure maximum efficiency. The exposed surface area is an important consideration in this aspect. Such criteria and/or parameters will be easily assessed by a person skilled in the art. Other criteria include the air flow speed, how polluted the air to be cleaned is, and what the pollutants are.

According to one embodiment, the air cleaning device is placed between the tobacco and the filter of a cigarette. Thereby when cigarette smoke is inhaled, contaminants such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead, will bind to the RAM alloy and not be inhaled.

According to another embodiment, the air cleaning device is adapted in size and form to fit into or over a personal safety overall or costume, with or without accompanying mask and/or respiratory device.

According to another embodiment, the air cleaning device is adapted in size to fit in an exhaust tube to clean exhaust air, such as for cars, buses and other moving vehicles. The air cleaning device will, in that particular case, replace the

catalytic systems used nowadays.

According to yet another embodiment, the air cleaning device is used in factories to clean the fumes generated in the course of industrial production and then released into the atmosphere. The air cleaning device may be placed in chimneys with or without the additional feature of steam which is channelled in together with the fumes leading to the cleaning device. When the heated smoke pass through the air cleaning filter the pollutants bind to the filter allowing clean air to be released.

According to another embodiment, the air cleaning device is used in all kinds of domestic or industrial ventilation systems to clean the air of air pollutants including microorganisms.

Further the invention relates to the use of the air cleaning device for the cleaning of polluted air such as, air inhaled after smoking tobacco products or in a smoke-filled environment, and air passing through domestic and industrial ventilation and exhaust systems, including those used in transportation vehicles.

## EXAMPLES

Example 1 given below illustrates the invention. These examples are present to exemplify the invention; they are not, however, intended to limit in any way the invention as covered by the claims.

Example 1: To show the effect of using the air cleaning device in cigarettes

*Method:*

The cigarettes were first smoked. A common filter was used as a control. The test filter contained RAM. All cigarettes were smoked with a plastic tube. The smoke was guided through a tested filter membrane. The tested filter membrane was weighed before and after smoking. The amount of tar was calculated by the difference of filter weight before and after smoking.

*Experimental:*

The experimental setup (A) is shown in Figure 1.

*Results:*

1. A comparison of the amount of heavy metal present in a smoked and unsmoked RAM filter membrane is given in Table 1.

Table 1: Amount of heavy metal present in a smoked and unsmoked RAM filter membrane.

| Metals | Smoked RAM (mg/kg*) | RAM (mg/kg) |
|---|---|---|
| Silver (Ag) | <9 | <9 |
| Cadmium (Cd) | <0.3 | <0.3 |
| Cobalt (Co) | <0.3 | <0.3 |
| Chromium (Cr) | <0.6 | <0.6 |
| Copper (Cu) | 490000 | 484000 |
| Mercury (Hg) | <3 | <3 |
| Manganese (Mn) | <1 | <1 |
| Nickel (Ni) | 16.1 | 26.6 |
| Lead (Pb) | 51.5 | <3 |
| Vanadium (V) | <0.3 | <0.3 |
| Zinc (Zn) | 474000 | 508000 |

(* i.e., mg (heavy metal)/kg (filter membrane))

2. A comparison of the amount of heavy metal present in a smoked filter membrane with and without RAM is shown in Table 2 below.

Table 2: Amount of heavy metal present in a smoked filter membrane with and without RAM.

| Metals | Filter with RAM (mg/kg) | Filter without RAM (mg/kg) |
|---|---|---|
| Ag | <0.2 | <0.09 |
| Cd | 0.163 | 0.207 |
| Co | 0.0629 | 0.140 |
| Cr | 1.25 | 0.551 |
| Cu | 770 | 171 |
| Hg | <0.02 | <0.01 |
| Mn | 0.587 | 2.45 |
| Ni | 0.977 | 0.495 |
| Pb | 1.22 | 0.246 |
| Zn | 7500 | 55.9 |

*Conclusions:*

- The results given in Table 1 indicate that smoking increases the amount of heavy metal content, especially lead (Pb), deposited in the cigarette filters.

- The results given in Table 2 indicate that a significantly greater amount of heavy metal is trapped in the filter membranes comprising RAM.

## CLAIMS

1. An air cleaning device, comprising at least a copper-zinc alloy.

2. The air cleaning device according to claim 1, wherein the alloy is redox alloy media (RAM).

3. The air cleaning device according to any of the preceding claims, wherein the air pollutants removed or reduced in level by the cleaning device is selected from the group consisting of metals such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, lead and microorganisms.

4. The air cleaning device according to any of the preceding claims, wherein more than 50%, such as from about 50% to about 70 %, such as up to 90%, of the heavy metal content in cigarette tar is removed.

5. The air cleaning device according to any of the preceding claims, wherein the device is reusable.

6. A method to remove pollutants from polluted air comprising the steps of;
   a) providing an air cleaning device according to any of the preceding claims,
   b) allowing polluted air pass through the air cleaning device,
   c) allowing the pollutants to bind to the air cleaning device, and
   d) obtaining air substantially free from pollutants.

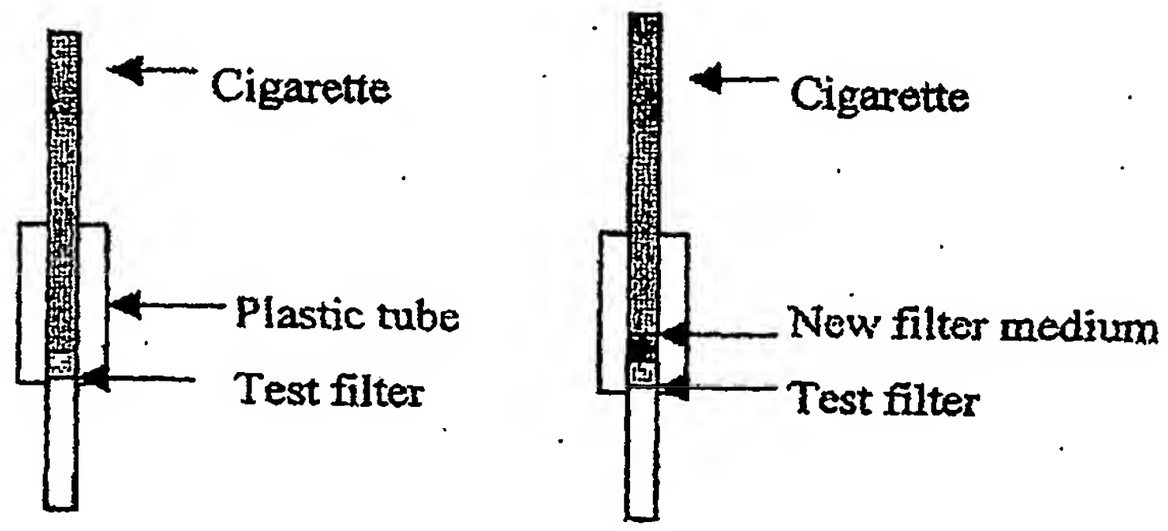
7. The method according to claim 6, wherein an additional step of applying steam is used in between a) and b).

8. Use of the air cleaning device according to any of the claims or the method according to claims 6-7 for the cleaning of polluted air, such as air obtained from smoked tobacco products, in a smoke-filled environment, from domestic and industrial ventilation and exhaust systems including exhaust systems employed in vehicles.

## ABSTRACT

The invention relates to an air cleaning device, comprising at least a copper-zinc alloy and a method to clean polluted air, such as, air inhaled after smoking tobacco products or in a smoke-filled environment, and air passing through domestic and industrial ventilation and exhaust systems, including those used in transportation vehicles.

Figure 1: The experimental set-up of the filter test in cigarettes.




Control

New filter medium